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Exhaust gas purification system for a motor vehicle having a reducing agent storage tank, and associated operating method

The invention relates to an exhaust gas purification system for a motor vehicle, for which predetermined maintenance intervals are provided, having a reducing agent storage tank for storing a reducing agent intended for the exhaust gas purification, and to a method for operating a motor vehicle having an exhaust gas purification system in accordance with the preamble of claim 4.

Exhaust gas purification systems of the abovementioned type are known in particular for motor vehicles driven by diesel engines, which have what is known as an SCR catalytic converter for removing nitrogen oxides from the exhaust gas. This allows the reduction of nitrogen oxides from the exhaust gas fed to it even under oxidizing conditions, i.e., with an exhaust gas which has an excess of oxygen. However, a precondition for this is that a reducing agent which has a selective activity with regard to the reduction of nitrogen oxides be added to the exhaust gas. Such reducing agents include, inter alia, primarily ammonia and substances which can release ammonia. In particular, urea or ammonium carbamate are customary and are preferably carried in a corresponding tank in the motor vehicle, preferably in the form of an aqueous solution. This reducing agent therefore constitutes an additional operating fluid which has to be topped up at regular intervals in order to ensure the long-term exhaust gas purification function. This represents additional outlay and requires careful handling in order to minimize associated risks, for example caused by incorrect usage of the reducing agent.

Therefore, it is an object of the invention to provide an exhaust gas purification system for a motor vehicle and a method for operating a motor vehicle having an exhaust gas purification system, which ensure correct, economical usage of a reducing agent intended for the exhaust gas purification.

This object is achieved by an exhaust gas purification system having the features of claim 1 and by a method having the features of claim 4.

The exhaust gas purification system according to the invention is distinguished by the fact that the filling capacity of the reducing agent tank is selected in such a way that it amounts to at least a level predetermined by an assumed reducing agent consumption during the maintenance interval.

Typically, maintenance intervals are generally provided for motor vehicles; after the end of these maintenance intervals, wearing parts require maintenance and/or consumables need to be replaced or topped up. With some consumables, such as for example wiper water liquids, it is expedient if topping up can also be carried out by the owner or driver of the motor vehicle himself. In the case of other consumables, such as for example the transmission oil, by contrast, this is often undesirable, for example because there is a risk of incorrect handling. This also applies to the reducing agents which are used for exhaust gas purification purposes and are carried in the motor vehicle. The most suitable reducing agent is an aqueous solution of urea or ammonium carbamate, in which case incorrect handling, for example caused by inadvertently drinking or shaking the liquids, needs to be avoided. Moreover, it is desirable to relieve the owner of the vehicle of the need to check the availability of the additional operating fluid, in particular also because if care is not taken the reducing agent under certain

circumstances will not be topped up at the correct time, and consequently exhaust gas purification can no longer take place. These risks are avoided by the dimensioning of the reducing agent tank with respect to the vehicle maintenance intervals in accordance with the invention.

In the present context, the term maintenance interval is to be understood as meaning an interval, which is dependent on a running distance or a running time, between stipulated workshop visits as are customarily provided for maintaining correct operation of the motor vehicle. These are expediently predetermined by the vehicle manufacturer according to certain criteria. The dimensioning of the reducing agent tank according to the invention makes it unnecessary to top up the reducing agent within the maintenance intervals, since the reducing agent tank is dimensioned in such a way that it can accommodate at least a quantity of reducing agent which is likely to be required within a maintenance interval. It is therefore possible for the reducing agent to be topped up exclusively during workshop visits by trained staff during the regular maintenance work as stipulated. The need for the owner of the vehicle to hold stocks of the reducing agent and to top up the reducing agent is eliminated. This also eliminates the associated risks as well as the additional work on the part of the owner of the vehicle. Moreover, the outlay required to set up an extensive supply infrastructure, which is correspondingly expensive, is eliminated.

In a configuration of the invention, the reducing agent tank has a closure apparatus which is to be opened for topping-up purposes, the closure apparatus being protected against being opened outside a maintenance operation which is to be carried out by authorized maintenance staff after the maintenance interval has elapsed. This avoids the reducing agent being topped up

by untrained staff, and the associated risks are eliminated. It is preferable for the reducing agent tank to be provided with a special closure which can only be opened by trained and/or authorized maintenance staff. By way of example, an electronically coded closure which can only be unlocked and opened by authorized staff is advantageous. Therefore, the handling of the reducing agent remains the responsibility of this trained staff, and danger to the environment, objects and people is avoided. On account of the fact that the monitoring of the level is no longer the responsibility of the vehicle owner, there is also no risk of the reducing agent not being topped up even when required, for example in order to save costs.

In a further configuration of the invention, level monitoring is provided for the purpose of monitoring the quantity of reducing agent that is present in the reducing agent tank, in such a manner that a warning signal is output when the level drops below a residual filling quantity which results from the remaining running time until the end of the maintenance interval and an assumed consumption rate. Accordingly, the driver of the motor vehicle is informed of a level which has dropped critically. This takes account of the fact that topping-up may be required even before a maintenance interval which is usually provided on the basis of other criteria has ended, on account of unforeseen circumstances. This is considered the equivalent of a maintenance interval expiring.

The method according to the invention is distinguished by the fact that, at a reducing agent storage tank for storing a reducing agent intended for exhaust gas purification, a closure device for the reducing agent storage tank is locked such that it cannot be opened over the course of the maintenance intervals and is unlocked and opened during a maintenance operation

after the end of the maintenance interval in order for the reducing agent to be topped up. Therefore, within the maintenance interval the reducing agent tank cannot be opened, ensuring that the topping-up of the reducing agent is carried out during the intended maintenance, for example in a franchised workshop.

In a configuration of the method, the filling quantity of reducing agent in the reducing agent tank is determined, and a warning signal is output if this quantity drops below a predeterminable minimum filling level. In this way, the need to top up or the need for unplanned maintenance on account of the level being too low is indicated in good time.

In a further configuration of the method, a consumption rate for the reducing agent is determined, and this information is used to determine the reducing agent consumption quantity which is to be expected by the end of the maintenance interval, and a warning signal is output if the expected consumption quantity exceeds the filling quantity. This procedure allows realistic estimation of the predicted time of topping up. It is also possible to make do without the outputting of a warning signal if the remaining time or running distance until the intended time of topping up is longer than the time which is in any case intended for carrying out stipulated maintenance.

In a further configuration of the method, after a predeterminable motor vehicle running distance with a warning signal being output has been exceeded, intervention measures are taken in the operation of the motor vehicle, in such a manner as to effect a reduced consumption rate for the reducing agent. Therefore, if the warning signal warning of the need to top up the reducing agent is ignored, emergency running mode is set, in which the consumption of reducing agent is reduced, so that the range which otherwise remains is

increased. It is preferable for the consumption of reducing agent to be reduced in such a manner that a predeterminable minimum exhaust gas purification function is still provided. As an additional measure, it is possible to input an entry into a readable error memory. If a predeterminable motor vehicle running distance with a warning signal being output is exceeded, it is also possible to provide for the vehicle drivability to be restricted, for example by activating a predeterminable speed limiter or engine speed limiter.

The text which follows describes advantageous embodiments of the invention on the basis of examples, which consider, by way of example, a motor vehicle with a diesel engine and an exhaust gas purification system which comprises what is known as an SCR catalytic converter.

The SCR catalytic converter is preferably designed to reduce the levels of nitrogen oxides by using a selective reducing agent. The latter may, for example, be liquid ammonia or urea. In the text which follows, it is assumed that the reducing agent is urea, preferably in the form of an aqueous solution, which is carried with the vehicle in a tank provided for this purpose. The text which follows refers in general terms to a urea tank.

For the motor vehicle, there are stipulated maintenance intervals, after the end of which prescribed maintenance work, such as for example a transmission or engine oil change, needs to be carried out. This maintenance work is carried out in an authorized workshop. The stipulated maintenance intervals may differ in duration and depend primarily on the vehicle running distance together with consumption times for consumables or service lives of various components which are subject to wear.

According to the invention, the size of the urea tank is determined from the likely consumption of urea during a maintenance interval. Dependent on the particular conditions, such as for example the installation space available, it is expedient to work on the basis of longer or shorter maintenance intervals. The consumption of urea within the maintenance interval is preferably determined from the nitrogen oxide emissions from the engine and the reduction in nitrogen oxide levels to be achieved by means of the use of urea. Since the nitrogen oxide emissions from the engine are dependent on driving conditions, it is in turn expedient to work on the basis of the maximum total nitrogen oxide emissions to be expected within the maintenance interval. Alternatively, it is possible to provide for the nitrogen oxide emissions which occur with a predeterminable probability during the maintenance interval to be used as the starting point. In this case, it is possible to make statistical statements about the probability of driving profiles and associated nitrogen oxide emissions.

A level monitoring device is expediently provided for a urea tank which has been dimensioned in this way. This level monitoring device can on the one hand record the occurrence of a predeterminable minimum filling level and cause a corresponding warning signal to be output when this minimum filling level is reached. The warning signal preferably at the same time provides information about the residual running time or residual running distance which is likely to remain. On the other hand, the level monitoring device can also ascertain the current level on an ongoing basis and form a relationship between the previous consumption and the engine operating parameters or engine nitrogen oxide emissions which were in each case present. It is in this way possible to estimate the residual running time

which remains with a high degree of accuracy. If it is ascertained that topping up is likely to be due before the end of the maintenance interval which is generally specified in any case, this information is also indicated, and it is preferable to reset the expiry of the maintenance interval according to the residual running time. A standard display unit can be provided for outputting the abovementioned information.

If topping up does not take place as indicated, to maintain a predeterminable minimum function of the exhaust gas purification device, it is advantageous to switch vehicle operation to an emergency running mode. This may comprise prohibiting certain engine operating points with a predeterminable increased emission of untreated nitrogen oxides. As an alternative or in addition, it is possible to reset engine maps, so as to lower the emission of nitrogen oxides from the engine, even if this is to the detriment of the fuel consumption. In this way, the residual running time which remains for the quantity of urea that is still available is drawn out. In this context, it is also possible to provide for the urea metering strategy to be modified in such a manner that although the extent to which the nitrogen oxide levels are reduced decreases, it does not drop below a predeterminable level. It is in this way at least possible to limit the release of nitrogen oxides to the environment, which occurs to an increased extent when there is a shortage of urea or when the urea tank is empty. To make the urgency of topping up clear, it is also possible to provide for the drivability of the vehicle to be restricted, for example by automatic speed limiting and/or engine speed limiting, preferably in conjunction with the indication of a corresponding message. The restrictions may also be gradual and become increasingly severe as the reducing agent becomes more and more scarce.

If the urea tank is completely emptied, it is even possible to provide for restarting of the vehicle to be prevented by a suitable block after the vehicle has been switched off. This prevents the vehicle from continuing to drive on the roads without an exhaust gas purification function. It is preferably provided, at any rate, that incorrect operation or lack of operation with regard to the urea metering be stored in a readable error memory by the corresponding information being input.

According to the invention, a special top-up opening is provided for the urea tank. This opening is distinguished by a closure which is prevented from unauthorized opening, in particular during the maintenance interval. It is preferable for this closure to be such that it can only be opened during the intended maintenance work after a maintenance interval has elapsed, but is otherwise locked. For this purpose, it is advantageous to provide a block, for example controlled by software, which can only be released by inputting a code so as to open up the top-up opening; in this case, the code, by way of example, is only available to authorized workshops. It is also advantageous for a connection to an electronic control or diagnosis device to be provided for this block. The block can then be unlocked by a suitable connection, for example an adaptor provided for this purpose, which is preferably only available to workshop staff at an authorized workshop. To guarantee this function, it is also possible to provide for it to be necessary to input a code. Alternatively, a special key or a special tool which is only available to authorized staff can be provided for the closure. In the simplest case, it is also possible to prevent unauthorized opening of the closure by means of a seal.

These measures which have been outlined mean that the urea tank can only be topped up by authorized and

trained staff, preferably at a franchised workshop. This avoids inappropriate or incorrect usage of the reducing agent, such as for example incorrect topping up, shaking or unintentional consumption. In addition to the safety function which has been outlined, topping up is also made simpler for the owner or driver of the vehicle, since the latter no longer has to top up the urea tank himself.